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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B32B 15/01, C22C 21/00, F16C 33/12	A1	(11) International Publication Number: WO 96/11800 (43) International Publication Date: 25 April 1996 (25.04.96)

(21) International Application Number: PCT/BR95/00034

(22) International Filing Date: 28 July 1995 (28.07.95)

(30) Priority Data:
PI 9403710-8 13 October 1994 (13.10.94) BR

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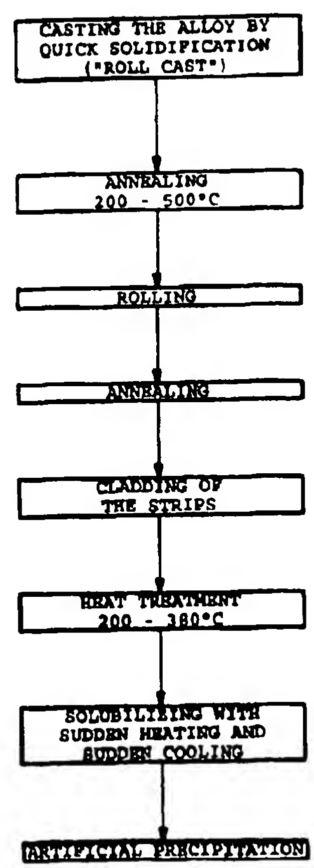
(81) Designated States: CA, MX, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: A BIMETALLIC STRIP FOR A SLIDING BEARING AND PROCESS FOR PRODUCING SAID BIMETALLIC STRIP

(57) Abstract

A bimetallic strip for a sliding bearing and process for producing said bimetallic strip, the latter being of the type comprising a sliding strip (1), which is made of aluminium alloy and which is adhered to a supporting strip (2), which is usually made of steel and which is optionally coated with a nickel coating interlayer (3). The process comprises the following steps) a- casting by the quick solidification process (roll cast) an alloy comprising from 3 to 30 % of tin, from 1 to 6 % of silicon and the remaining being of aluminium and accidental impurities, by pouring the cast alloy between two cold rolling cylinders, in order to obtain at least 95 % of the silicon particles smaller than 3.5 microns and an aluminum grain average size of about 6 microns; b) annealing the aluminium alloy sliding strip (1) in a heater at a temperature range from 200 to 500 °C; c) setting, optionally, the thickness of the sliding strip (1), through cold rolling passes, followed by respective annealings, as defined in the previous step; d) hot rolling (cladding) together the sliding strip (1) and the steel supporting strip (2), in order to form the bimetallic strip; e) heat treating the bimetallic strip between 200 and 380 °C, so as to obtain a metallurgical bonding between the strips; f) subjecting the metallic strip to a solubilizing process of the intermetallic compounds of the aluminum alloy, by sudden heating at 380-500 °C, followed by sudden cooling; and g) subjecting the bimetallic strip to an artificial precipitation treatment in a heater, at a temperture from 150 to 250 °C.



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A BIMETALLIC STRIP FOR A SLIDING BEARING AND PROCESS FOR PRODUCING SAID BIMETALLIC STRIP

Field of the Invention

The present invention refers to a bimetallic strip, which is used in the formation of sliding bearings for internal combustion engines and which comprises a strip, which is made of an anti-friction or sliding material in aluminum base alloy usually containing silicon, tin and copper and which is adhered to a steel supporting strip. The present invention is also related to a process for producing said bimetallic strip.

Background of the Invention

The internal combustion engines have been designed to work with increasingly higher speeds and loads, thereby requiring sliding bearings, which are able to support these increasingly severer operational conditions, through improved fatigue resistance and anti-sticking characteristics, and which can operate with forged steel or cast iron crankshafts, without the need to protect the bimetallic strip with a lead/tin electrodeposited overlayer.

It is known that the high fatigue resistance characteristics of these aluminum base alloys result from a finer and more uniform distribution of the silicon particles in the aluminum phase.

Nevertheless, the known alloys of these type, such as that described in U.S. Patent 4,696,867, still present a silicon particle distribution which, in spite of a possible addition of small amounts of strontium or sodium to said alloys, does not reach a desirable refining to obtain a load capacity compatible with the operational requirements of the modern internal combustion engines.

The grain size of the known alloys of this type is from

about 20 to 50 μm, avoiding the achievement of substantial increases of fatigue resistance in the produced bimetallic strips (see fig.3 in the drawings). Besides de inconveniences cited above, it should be observed that the tin porcentages of about 8% or more in the alloy composition do not allow said alloy, after its usual casting, to be hot rolled to the desired thickness for the sliding strip, because hot rolling these alloys presents the risk of the tin being squeezed out.

Another deficient aspect of the known solutions refers to the lack of treatment steps of the bimetallic strip, so as to obtain, in the sliding strip, a compound that is capable of hardening the aluminum alloy, increasing even more its fatigue resistance through a more accentuated silicon refining.

These prior art aluminum alloys are cast into billets with a shape which is very different from that to be attained by the sliding strip, thus making difficult and costly the manufacturing process of the bimetallic strip and the achievement of the minimum silicon refining in the alloy structure.

Disclosure of the Invention

It is an objective of the present invention to provide a bimetallic strip for sliding bearings, which comprises an aluminum base alloy containing silicon and tin and which presents a structure with a high degree of silicon-tin refining, improved properties of fatigue resistance, anti-sticking and adherence to a supporting strip, without requiring the presence of strontium or sodium in the composition of the aluminum alloy and without leading to risks of the tin being squeezed out during the hot rolling steps of the sliding strip material.

Another objective of the invention is to provide a

process which allows to obtain the above cited bimetallic strip in a economically feasible way.

Brief Description of the Drawings

The invention will be described below, with reference to the attached drawings, in which:

Fig. 1 is a sectional view of a length portion of a bimetallic strip of the type used in the present invention;

Fig. 2 is a block diagram, illustrating the steps of the manufacturing process of the bimetallic strip shown in fig. 1;

Fig. 3 is a metallographic representation of the sliding strip structure of a bimetallic strip produced in accordance with the prior art;

Fig. 4 is a metallographic representation similar to that of fig. 3, but relative to the sliding strip of the bimetallic strip the present invention; and

Fig. 5 is a block diagram, illustrating the steps in the manufacturing process of the bimetallic strip including an aluminum interlayer.

Best Mode for Carrying out the Invention

According to a first aspect of the invention with respect to figure 1, the bimetallic strip comprises a sliding strip 1, which is made of an aluminum base alloy, and which is adhered to a supporting strip 2 usually in steel, through a nickel coating layer 3 applied onto the supporting strip 2.

The aluminum alloy comprises from 3 to 30% of tin; from 1 to 6% of silicon and the remaining being of aluminum and accidental impurities. It has the shape of a strip, which is cast by quick solidification, with a thickness sligthly superior to that of the sliding strip 1 to be formed onto the supporting strip 2, said sliding strip 1 being structurally solubilized and artificially precipitated, in order to present an aluminum grain

size of about 6 μm. This alloy has the silicon hard particles finely dispersed in the aluminum matrix, as illustrated in figure 4, at least 95% of said particles being smaller than 3.5 microns.

In a preferred composition, the alloy may further include at least one of the hardening elements: Ni, Mn, Cr, Cu and Ti, in the range from 0.05 to 5%, with the aim of increasing the mechanical properties and the wear, fatigue and sticking resistances.

In case the alloy is provided with one or more of the above additives, at least 95% of the silicon hard particles will be smaller than 3.5 microns and 5%, at maximum, will vary from 3.5 to 5 microns.

According to a second aspect of the invention related to figure 2, the process for producing the above cited composite material comprises the following steps:

a- casting by the quick solidification process (roll cast) an alloy comprising from 3 to 30% of tin, from 1 to 6% of silicon, optionally from 0.05 to 5% of at least one of the hardening additives mentioned above and the remaining being of aluminum and accidental impurities, by pouring the cast alloy between two cold rolling cylinders.

b- annealing the aluminum alloy sliding strip 1 in a heater at a temperature range from 200 to 500^{o}C;

c- setting, optionally, the thickness of the sliding strip 1, through cold rolling passes, followed by respective annealings, as defined in the previous step;

d- hot rolling (cladding) together the sliding strip 1 and the steel supporting strip 2 coated with a nickel film 3, in order to form the bimetallic strip;

e- heat treating the bimetallic strip between 200 and 380^{o}C, so as to obtain a metallurgical bonding between the strips;

f- subjecting the bimetallic strip to a solubilizing

process of the intermetallic compounds of the aluminum alloy, by sudden heating at 380-500^{o}C, followed by sudden cooling; and

g- subjecting the bimetallic strip to an artificial precipitation treatment in a heater, at a temperature from 150 to 250^{o}C.

The casting step by quick solidification (roll cast) allows the production of a sliding strip 1, which has been quickly solidified by the metallic bath and which has a reduced thickness, in milimeters, that is already very close to the thickness to be maintained in the final product. Said sliding strip further presents a quite refined structure, mainly in terms of silicon and tin dispersion in the aluminum phase. The refining of the hard particles, i.e., silicon and silicon compounds, reaches a level in which 100% of the particles are smaller than 3.5 microns. Optionally, the alloy may contain the above cited hardening additive elements and have the dimension of the hard particles controlled, in order to obtain 95% of the particles smaller than 3.5 microns and the remaining 5% varying from 3.5 to 5 microns. Thus, it is possible to initiate the manufacture of a product which is more resistant to fatigue and sticking than those known products, by using an aluminum alloy containing silicon, tin and copper, but without strontium or sodium, which the prior art considers as adequate for better refining the structure of this kind of alloy.

Another unexpected effect in the alloy structure, in function of the casting process, is that the sliding strip 1 may be hot rolled at high temperatures, without the tin being squeezed out, even when said tin is found in porcentages higher than 8%.

The solubilizing step may be achieved, by said bimetallic strip being subjected to a liquid bath, such

as a lead bath, said bimetallic strip being then subjected to sudden cooling through jets of water, for example. This treatment promotes a substantial increase in the load capacity of the bimetallic strip to be produced.

The artificial precipitation is made in heaters, whereto the coils are fed in a discontinuous way.

The bimetallic strip may then be shaped for producing the sliding bearing.

Another unexpected aspect of the invention resides in the fact that the average size of the aluminum grain, corresponding to 50 microns in the prior art, is reduced to about 6 microns in the new sliding strip 1, which is obtained by roll cast or hot cladding.

Figure 5 illustrates a variant of the process, in which there is provided a nickel or aluminum interlayer, onto which a sliding strip is formed and rolled, the latter being obtained by quick solidification.

CLAIMS

1. A bimetallic strip for a sliding bearing, comprising a sliding strip (1), which is made of aluminum alloy and which is adhered to a supporting strip (2), which is usually made of steel and which is optionally coated with a nickel coating interlayer (3), <u>characterized</u> in that the weight of the sliding strip (1) consists from 3 to 30% of tin; from 1 to 6% of silicon and the remaining being of aluminum and accidental impurities, said sliding strip having at least 95% of the silicon hard particles smaller than 3.5 microns and an aluminum grain average size of about 6 microns.

2. A bimetallic strip, as in claim 1, <u>characterized</u> in that the aluminum alloy of the sliding strip (1) further includes, by weight, from 0.05 to 5% of at least one of the following hardening elements: Ni, Mn, Cr, Cu and Ti, said alloy presenting at least 95% of the silicon hard particles and hardening additive elements smaller than 3.5 microns and, at maximum, 5% varying from 3.5 to 5 microns.

3. A bimetallic strip, as in claim 1 or 2, <u>characterized</u> in that it further comprises an interlayer, in one of the elements defined as nickel and aluminum, disposed between the sliding strip (1) and the supporting strip (2).

4. Process for producing a bimetallic strip for a sliding bearing, said bimetallic strip comprising an aluminum alloy sliding strip (1), adhered to a supporting strip (2), usually in steel and optionally coated with a nickel coating interlayer (3), <u>characterized</u> in that it comprises the following steps:
a- casting by the quick solidification process (roll cast) an alloy comprising from 3 to 30% of tin, from 1 to 6% of silicon and the remaining being of aluminum

and accidental impurities, by pouring the cast alloy between two cold rolling cylinders, in order to obtain at least 95% of the silicon particles smaller than 3.5 microns and an aluminum grain average size of about 6 microns;

b- annealing the aluminum alloy sliding strip 1 in a heater at a temperature range from 200 to 500°C;

c- setting, optionally, the thickness of the sliding strip 1, through cold rolling passes, followed by respective annealings, as defined in the previous step;

d- hot rolling (cladding) the sliding strip 1 and the steel supporting strip 2 together, in order to form the bimetallic strip;

e- heat treating the bimetallic strip between 200 and 380°C, so as to obtain a metallurgical bonding between both strips;

f- subjecting the bimetallic strip to a solubilizing process of the intermetallic compounds of the aluminum alloy, by sudden heating at 380-500°C, followed by sudden cooling; and

g- subjecting the bimetallic strip to an artificial precipitation treatment in a heater, at a temperature from 150 to 250°C.

5. Process, as in claim 4, <u>characterized</u> in that the sliding strip (1) which is being cast in step <u>a</u> comprises from 0.05 to 5% of at least one additive hardening element selected from the group consisting of Ni, Mn, Cr, Cu and Ti.

6. Process, as in claim 5, <u>characterized</u> in that the sliding strip (1) presents at least 95% of the silicon particles and additive hardening elements smaller than 3.5 microns and, at maximum 5% varying from 3.5 to 5 microns.

7. Process, as in any of claims 4, 5, or 6, <u>characterized</u> in that the sliding strip (1) is cast by

quick solidification together with its rolling onto an aluminum or nickel strip, which defines an interlayer between the sliding strip (1) and the supporting strip (2).

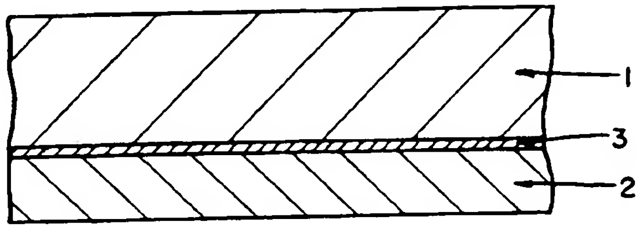

FIG.1

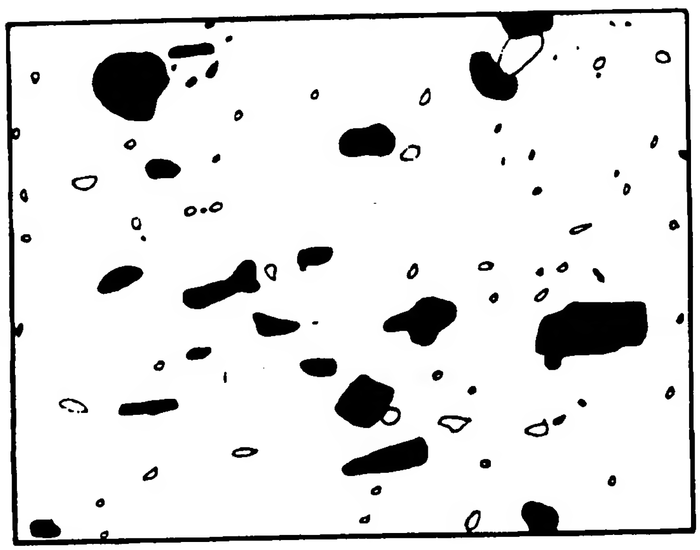

FIG.3
PRIOR
ART

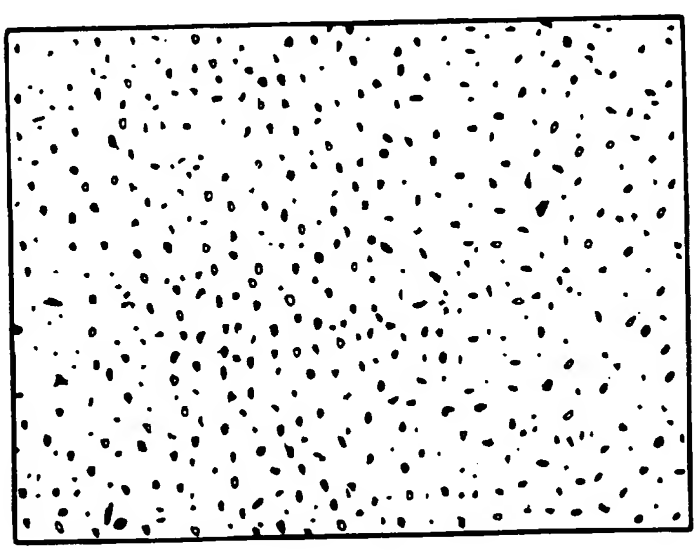

FIG.4
INVENTION

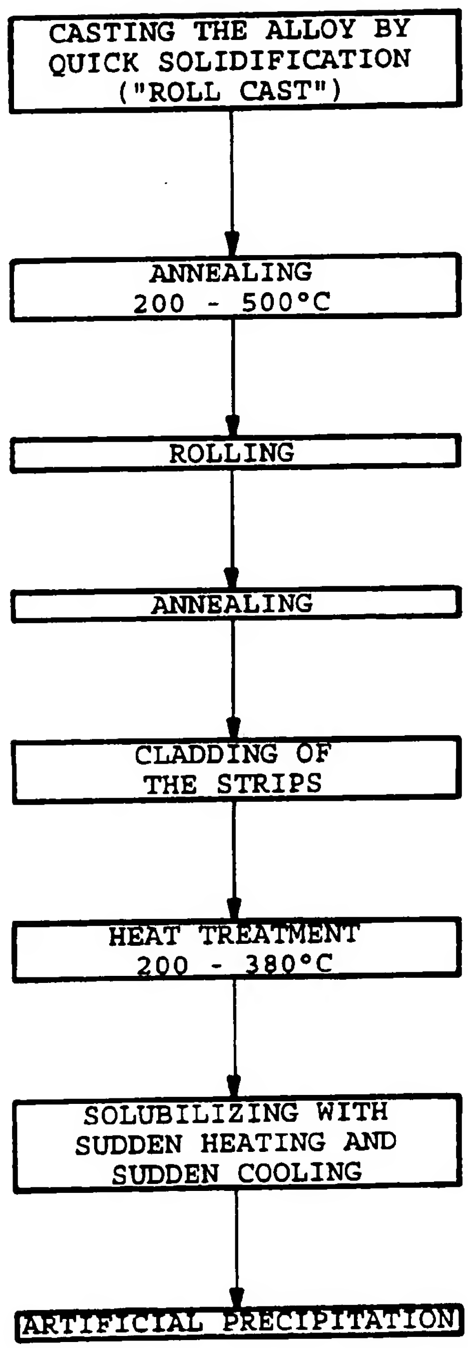
CASTING THE ALLOY BY QUICK SOLIDIFICATION ("ROLL CAST")
ANNEALING 200 - 500°C
ROLLING
ANNEALING
CLADDING OF THE STRIPS
HEAT TREATMENT 200 - 380°C
SOLUBILIZING WITH SUDDEN HEATING AND SUDDEN COOLING
ARTIFICIAL PRECIPITATION

FIG.2

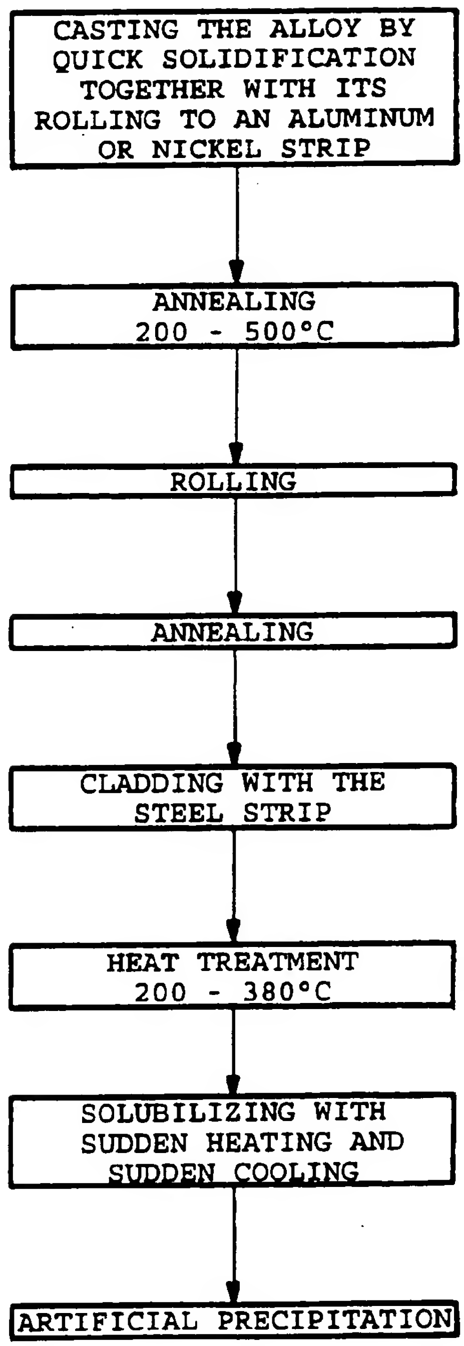
CASTING THE ALLOY BY QUICK SOLIDIFICATION TOGETHER WITH ITS ROLLING TO AN ALUMINUM OR NICKEL STRIP
ANNEALING 200 - 500°C
ROLLING
ANNEALING
CLADDING WITH THE STEEL STRIP
HEAT TREATMENT 200 - 380°C
SOLUBILIZING WITH SUDDEN HEATING AND SUDDEN COOLING
ARTIFICIAL PRECIPITATION

FIG.5

INTERNATIONAL SEARCH REPORT

Inte   nal Application No
PCT/BR 95/00034

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   B32B15/01   C22C21/00   F16C33/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   B32B C22C F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE,A,37 30 862 (GLYCO-METALL-WERKE DAELEN & LOOS) 23 March 1989 see the whole document ---	1,4
Y	FR,A,2 189 527 (ALCAN RESEARCH AND DEVELOPMENT LTD.) 25 January 1974 *Claims 1-8* ---	1,4
Y	FR,A,2 124 748 (GLACIER METAL COMPANY LTD.) 22 September 1972 *Claims 1-26* ---	1,4
A	US,A,3 268 369 (D.E.HAUGEN) 23 August 1966 see the whole document ---	1,4
A	US,A,4 471 029 (FUKUOKA ET AL.) 11 September 1984 *Claims 1-10* ---	1,2
	-/--	

[X] Further documents are listed in the continuation of box C.   [X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 October 1995	24. 10. 95

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Inte nal Application No
PCT/BR 95/00034

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 471 033 (FUKUOKA ET AL.) 11 September 1984 *Claims 1-10* ---	1,2
A	DE,A,36 31 029 (NDC CO.LTD.) 26 March 1987 see the whole document -----	1-3

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte   nal Application No
PCT/BR 95/00034

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